A. INVITED TALKS

IT01:

THE FUTURE OF NUCLEAR PHYSICS IN EUROPE AND THE DEMANDS ON ACCELERATOR TECHNIQUES

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Future large-scale facilities for research are very much under discussion in Europe. This results, of course, on the one hand from the discussions in the science communities and their identification of new frontiers in research; but it also reflects to a certain degree the trend to pool resources among the countries towards what has been labeled the "European Research Area".

In the field of nuclear physics and/or its intersections with particle physics, several such efforts have been under consideration or are underway. This applies to the study of the subnuclear degrees of freedom of the strong interaction system(s) as well as to the extremes of the atomic nucleus as the many-body system of the strong force.

In this talk an attempt is made to summarize the present status and future plans, with emphasis on the facility concepts and their demands on accelerator technology and development

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IT02:

OVERVIEW OF THE DIAGNOSTICS SYSTEMS OF SOLEIL AND DIAMOND

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SOLEIL and DIAMOND are two third-generation light sources in construction in France and in Great Britain respectively. SOLEIL is scheduled to deliver its first photons to its users in 2006 and DIAMOND in 2007. This talk will present the beam diagnostic systems of both projects with emphasizing technological novelties and the instruments that are essential to their performances: BPM system, profile monitors and feedback systems.

IT03:

SINGLE PASS OPTICAL PROFILE MONITORING

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Beam profiles are acquired in transfer lines to monitor extracted beams and compute their emittance. Measurements performed on the first revolutions of a ring will evaluate the matching of a chain of accelerators. Depending on the particle type and energy, these measurements are in general performed with screens, making either use of Luminescence or OTR [Optical Transition Radiation], and the generated beam images are acquired with detectors of various types: CCD, CMOS, CID, TV Tubes or Multi-Anode Photo-Multipliers. The principles, advantages and disadvantages of both families of screens will be discussed in relation with the detectors used. A possible evaluation method for luminescent screens and beam test results will be presented. Finally other optical methods used will be mentioned for completeness.

IT04:

CHALLENGES FOR LHC AND DEMANDS ON BEAM INSTRUMENTATION

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The LHC machine presently under construction at CERN will exceed existing superconducting colliders by about one order of magnitude for luminosity and beam energies for pp collisions. To achieve this performance the bunch frequency is as large as 40MHz and the range in beam intensity covers $5*10^9$ protons to $3*10^{14}$ protons with a normalised beam emittance as small as 3 umrad. This puts very stringent demands on the beam instrumentation to be able to measure beam parameters like beam positions, profiles, tunes, chromaticities, beam losses or luminosity. The presentation will pick out interesting subjects of the LHC beam instrumentation field. The examples will be chosen to cover new detection principles or new numerical data treatments, which had to be developed for the LHC as well as aspects of operational reliability for instrumentation, which will be used for machine protection systems.

IT05:

SINGLE SHOT ELECTRON-BEAM BUNCH LENGTH MEASUREMENTS

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It is recognised by the Instrumentation community that 4th generation light sources (like TESLA, LCLS) are posing some o the most stringent requirements on beam diagnostics. Among these, the single-shot electro-optic measurement of the bunch length and shape in the sub-picosecond domain is an ongoing development.

The electro-optic detection method makes use of the fact that the local electric field of a highly relativistic electron bunch moving in a straight line is almost entirely concentrated perpendicular to its direction of motion. This electric field makes an electro-optic crystal placed in the vicinity of the beam birefringent. The amount of birefringence depends on the electric field and is probed by monitoring the change of polarization of the wavelength components of a chirped, synchronized Ti:sapphire laser pulse.

This talk will provide details of the experimental setup at the Free Electron Laser for Infrared eXperiments (FELIX) in Nieuwegein, The Netherlands, where single shot images have been obtained of 1.7 ps long electron bunches (beam energy 46 MeV, charge per bunch 200 pC). Furthermore, future upgrading possibilities will be discussed.

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IT06:

SHORT BUNCH BEAM PROFILING

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The complete longitunal profiling of short electron bunches is discussed in the context of 4th generation light sources. The high peak current required for the SASE lasing process is achieved by longitudinal compression of the electron bunch. The lasing process also depends on of the preservation of the transverse emittance along the

bunch during this manipulation in longitudinal phase space. Beam diagnostic instrumentation needs to meet several challenges: The bunch length and longitudinal profile should be measured on a single bunch to characterize the instantaneous, peak current along the bunch. Secondly, the transverse emittance and longitudinal energy spread should be measured for slices of charge along the bunch. Several techniques for invasive and non-invasive bunch profiling will be reviewed, using as examples recent measurements from the SLAC Sub Picosecond Photon Source (SPPS) and the planned diagnostics for the Linac Coherent Light Source (LCLS). These include transverse RF deflecting cavities for temporal streaking of the electron bunch, RF zero-phasing techniques for energy correlation measurements, and electro-optic measurements of the wake-field profile of the bunch.

IT07:

DIGITAL SIGNAL PROCESSING IN BEAM INSTRUMENTATION: LATEST TRENDS AND TYPICAL APPLICATIONS

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During the last decade digital signal processing has found its way into the beam instrumentation arena, to become an essential part of several beam diagnostic systems. In fact, the recent impressive hardware performance improvement made it possible for functions once exclusively accomplished by analogue methods, to be enhanced by the application of an alternative digital approach. This is true to a point that the conversion to digital processing has become inevitable. Factors that favour crossing the border towards digital implementation are obviously speed as well as precision, signal-to-noise ratio, dynamic range, stability of components and configuration capability, together with the availability of powerful and user-friendly development tools. Improvement in A/D conversion and processing speed has allowed successfully developing digital feedback loops and on-line diagnostics. The ascent of such digital techniques generated a concurrent and parallel interest in digital signal processing algorithms and in the use of the associated digital hardware components. Current trends in beam diagnostics include using Digital Signal Processors (DSPs), Field Programmable Gate Arrays (FPGAs), digital receivers and fast digitizers. The talk reviews latest developments and illustrates selected digital applications, relevant to the beam diagnostic area.

IT08:

DIAGNOSTIC CHALLENGES AT SNS

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The Spallation Neutron Source now being built in Oak Ridge, Tennessee, USA, accelerates an H- ion beam to 1000 MeV with an average power of 1.4 MW. The H- beam is then stripped to H+, compressed in a storage ring to a pulse length of 695 ns, and then directed onto a mercury neutron spallation target. Most of the acceleration is accomplished with superconducting rf cavities. The presence of these cavities, the high average beam power, and the large range of beam intensity in the storage ring, provide unique challenges to the beam diagnostics systems. In this talk we will discuss these challenges and some of our solutions, including the laser profile monitor system, the residual gas ionization profile monitors, and network attached devices. Measurements performed using prototype instrumentation will also be presented.

IT09:

SMITH-PURCELL RADIATION IN VIEW OF PARTICLE BEAM DIAGNOSTICS

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The development of the next generation high quality electron beams which are necessary for future high luminosity linear colliders and short wavelengths free electron lasers requires sensitive and non–destructive beam diagnostic techniques. In this context Smith–Purcell radiation which is generated when a charged particle beam passes close to the surface of a periodic structure (diffraction grating) is under discussion as a compact and inexpensive beam profile monitor.

In order to study the basic emission process of Smith–Purcell radiation also in view of possible applications for particle beam diagnostics, experimental studies were performed at the Mainz Microtron MAMI in the visible spectral region with a microfocused 855 MeV electron beam. The radiation was separated from background components, as diffracted synchrotron radiation and transition radiation generated by electrons scratching the grating surface, by exploiting their specific emission characteristics. These are (i) the narrow emission cone in the direction perpendicular to the grating surface, (ii) the dispersion relation $| n | \lambda = D\,(1/\beta - \cos\theta)$ with n the diffraction order, β the reduced electron velocity, and θ the angle of observation, and (iii) the charcteristic intensity scaling as a function of the distance between beam axis and grating surface. Based on the experimental results the use of Smith–Purcell radiation as a longitudinal and transversal beam profile monitor will be discussed.

IT10:

ADVANCED DIAGNOSTICS OF LATTICE PARAMETERS IN HADRON COLLIDERS

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With a beam stored energy exceeding by several orders of magnitude the quench level of the magnets and non-negligible non-linear field components, the control of the beam dynamics and losses in LHC must be very precise. This is a strong incentive to strengthen as much as possible the potential of beam diagnostics. This paper reviews some of the developments in various laboratories that appear to have a large potential. They either allow for a much better access to classical beam parameters or for the measurement of quantities formerly not accessible. Examples are a fast measurement of the betatron tunes, the use of PLL for reliable tune tracking and feedback, new methods or ideas to measure the chromaticity with the potential of feedback systems and similarly for the betatron coupling, the measurement of high-order non-linear fields and resonances and the potential of AC dipole excitation. This list is bound to be incomplete as the field is fortunately very dynamic.

B. CONTRIBUTED TALKS

CT01:

AN INDUCTIVE PICK-UP FOR BEAM POSITION AND CURRENT MEASUREMENTS

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An Inductive Pick-Up (IPU) senses the azimuthal distribution of the beam image current. Its construction is similar to a wall current monitor, but the pick-up inner wall is divided into electrodes and each of which forms the primary winding of a toroidal transformer. The beam image current component flowing along each electrode is transformed to a secondary winding, connected to a pick-up output. Four pick-up output signals drive an active hybrid circuit, producing two difference signals proportional to the horizontal and vertical beam positions, and one sum signal, proportional to the beam current. The bandwidth of these signals, ranging from below 1kHz to beyond 150MHz, exceeds five decades. Each electrode transformer has an additional turn to which a pulse from a precise current source is applied to calibrate the sensor for accurate beam position and current measurements. The IPU has been developed for the drive beam linac of the CLIC Test Facility 3. For that purpose it had to be optimized for low longitudinal coupling impedance in the GHz range.

CT02:

SINGLE SHOT MEASUREMENTS OF THE 4-DIMENSIONAL TRANSVERSE PHASE SPACE DISTRIBUTION OF INTENSE ION BEAMS AT THE UNILAC AT GSI

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The UNILAC is used as an injector for the synchrotron SIS. It is designed to fill the synchrotron up to its space charge limit. The upper limit for the useful beam emittance of the UNILAC is given by the finite acceptance of the SIS during the injection process. In order to remain within this acceptance the emittance growth during beam acceleration and transportation due to space charge effects must be minimized by applying an appropriate beam focusing. Therefore, the influence of the magnetic focusing strength on the beam emittance growth was investigated experimentally for different beam currents. Measurements of transverse phase space distributions were performed before and after the Alvarez accelerator with a periodic focusing channel, respectively. In order to perform such a wide parameter scan within a reasonable time with respect to machine stability, the pepper pot technique was applied. The pepper pot method allows for single-pulse measurements. For comparison several measurements using the slit-grid technique, which averages over many pulses, were performed. Both transverse planes were measured simultaneously. Using two pepper pot devices more than 60 single shot measurements of the full 4-dimensional transverse phase space distribution were performed within 8 hours. In this paper we report on the results of the measurements and we compare them to beam dynamic simulations and we give an outlook on further developments on pepper pot devices.

CT03:

BEAM INSTRUMENTATION FOR THE SINGLE ELECTRON DAΦNE BEAM TEST FACILITY

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The DAΦNE Beam Test Facility (BTF) has been successfully commissioned in February 2002, and started operation in November of the same year. Although the BTF is a beam transfer line optimized for single particle production, mainly for high energy detectors calibration, it can provide electrons and positrons in a wide range of multiplicity: between 1-10^{10}, with energies from a few tens of MeV up to 800 MeV. The large multiplicity range requires many different diagnostic devices, from high-energy calorimeters and ionization/fluorescence chambers in the few particles range, to standard beam diagnostics systems. The schemes of operation, the commissioning results, as well as the beam diagnostics are presented.

CT04:

THE BEAM INHIBT SYSTEM FOR TTF II

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The new generation of light sources based on SASE Free-Electron-Lasers driven by LINACs operate with electron beams with high beam currents and duty cycles. This is especially true for the superconducting machines like TTF II and the X-RAY FEL, under construction or planning at DESY. Elaborate fast protections systems are required not only to protect the machine from electron beams hitting and destroying the vacuum chamber, but also to prevent the machine from running at high loss levels, dangerous for components like the FEL undulator.

This paper will give an overview over the different protection systems currently under construction for TTF II. The very fast systems, based on transmission measurements and distributed loss detection monitors, will be described in detail. This description will include the fast electronics to collect and to transmit the different interlock signals.

CT05:

BEAM LOSS DETECTION AT RADIATION SOURCE ELBE

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The Rossendorf superconducting Electron Linac of high Brilliance and low Emittance (ELBE) delivers an 40 MeV, 1 mA cw-beam for different applications such as bremsstrahlung production, electron channelling, free-electron lasers or secondary particle beam generation. In this energy region in case of collisions of the electron beam with the pipe nearly all beam power will be deposited into the pipe material. Therefore a reliable beam loss

monitoring is essential for machine protection at ELBE. Different systems basing on photo multipliers, compton diodes and long ionization chambers were studied. The pros and cons of the different systems will be discussed. Ionization chambers based on air-isolated RF cables installed some cm away parallel to the beam line turned out to be the optimal solution. The beam shut-off threshold was adjusted to 1 μC integral charge loss during a 100 ms time interval. Due to the favourable geometry the monitor sensitivity varies less than +/- 50 % along the beam line (different shielding conditions).

CT06:

TIMING SICKNESSES IN CONTROL SYSTEMS: CAUSES, CURE AND PREVENTION

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In some cases, Trigger Generators or Data Acquisition Systems used for Beam Diagnostics show undefined or unreliable timing behavior. This presentation identifies common reasons, ways to fix the problems and some general rules to avoid them from the beginning. Examples will be given to discuss causes for e.g. double bunches and timing and trigger jumps, periodic as well as randomly. It will be discussed, how proper layout, timing calculations and timing measurements can avoid these inconvenient effects in advance.

CT07:

FAST DSP USING FPGAs AND DSOs FOR MACHINE DIAGNOSTICS

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Digital signal processing using digital signal processors is now a mature field for machine diagnostics, giving significant benefits, in particular when used to analyze BPM signals for tune measurement and fast feedback systems. We discuss here digital signal processing using Field Programmable Gate arrays (FPGAs) with large gate counts and intelligent oscilloscopes. These offer great potential for the analysis of very fast signals to maximize the information extracted from high bandwidth sensors.
i) FPGAs allow data to be filtered numerically and treated at the speed of data collection of A/D converters in the 100MHz range. Parallel, fast and continuous treatment of BPM and FCT signals is possible. Examples are given of injection efficiency, turn by turn injection efficiency, turn by turn beam position, amplitude and phase calculation with averaging over each turn or many turns.
ii) Modern oscilloscopes include much computational power. In-built DSPs can perform correlations on the traces allowing the application of FIR filters. Some oscilloscopes incorporate a PC and allow on-board manipulation of the data using MATLAB. An example is given using an FIR applied to a 5GHz oscilloscope to extend its time response to measure electron bunch lengths less than 100ps with 1ps resolution.

CT08:

CAPABILITIES OF THE SLS MULTIBUNCH FEEDBACK ELECTRONICS

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Due to the unavailability of commercial ADC and DAC boards, first commissioning of the transverse multi bunch feedback was done in the last year using loaned equipment from Sincrotrone Trieste. In order to remedy that situation, development of ADC and DAC VME boards was started. The boards do a 500 MS/s data conversion with an 8 bit resolution. The ADC and DAC circuits are separate modules containing their own one to four de-/multiplexing electronic reducing the data rate to 125 MS/sec. The following stage being a common design to both ADC and DAC allows data recording and play back using on board RAM and allows freely programmable multiplexing/demultiplexing ratios of one to five to one to twelve. The digital data streams flow via Front Panel Digital Ports (FPDP). A special design criterion were low system latencies ensuring a high feedback efficiency. Apart from lab tests, we report on full feedback system test and show the feedback performance in the transverse and longitudinal planes.

CT09:

SLIM (SEM FOR LOW INTERCEPTION MONITORING) - AN INNOVATIVE NON-DESTRUCTIVE BEAM MONITOR FOR THE EXTRACTION LINES OF A HADRONTHERAPY CENTRE

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Real time monitoring of hadrontherapy beam intensity and profile is a critical issue for the optimisation of the dose delivery to the patient carcinogenic tissue, the patient safety and the operation of the accelerator complex. For this purpose an innovative beam monitor, based on the secondary emission of electrons by a non-perturbative, sub-micron thick Al target placed directly in the extracted beam path, is being proposed. The secondary electrons, accelerated by an electrostatics focusing system, are detected by a monolithic silicon position sensitive sensor, which provides the beam intensity and its position with a precision of 1 mm at 10 kHz frame rate. The conceptual design and the engineering study optimised for hadrontherapy, together with the results of the preliminary tests of the first system prototype, will be presented.

CT10:

BEAM DIAGNOSTICS IN THE AGOR CYCLOTRON

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The beam diagnostics equipment in modern multi-particle, multi-energy cyclotrons for research in nuclear physics is reviewed, using the superconducting cyclotron AGOR at the KVI as an example. An extensive set of diagnostics tools has been integrated already in the design stage. It includes three scanning probes for beam

centering, a scanning probe for the measurement of radial and vertical beam oscillations and beamlosses, beam phase pick-ups to optimize isochronism of the magnetic field and profile and current measurements along the beam path through the four movable extraction elements. The operating experience gained since the start-up of the cyclotron in 1996 is discussed for the various diagnostics tools and improvements are described.

CT11:

BEAM BASED HOM ANALYSIS OF ACCELERATING STRUCTURES AT THE TESLA TEST FACILITY LINAC

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The beam emittance in future linear accelerators for high energy physics and SASE-FEL applications depends highly on the field performance in the accelerating structures, i.e. the damping of higher order modes (HOM). Besides theoretical and laboratory analysis (network analyzer), a beam based analysis technique was established [S. Fartoukh, et.al., Proceedings of the PAC99 Conference] at the TESLA Test Facility (TTF) linac. It uses a charge modulated beam of variable modulation frequency to excite dipole modes. This causes a modulation of the transverse beam displacement, which is observed at a downstream BPM and associated with a direct analysis of the modes at the HOM couplers. Emphasis of this presentation is put on beam instrumentation and signal analysis aspects. A brief introduction of eigenmodes in resonant structures, as well as some interesting measurement results are further presented.

C. POSTER

PM01:

USE OF OPTICAL TRANSITION RADIATION INTERFEROMETRY FOR ENERGY SPREAD AND DIVERGENCE MEASUREMENTS

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OTR interferometry (OTRI) has been shown to be an excellent diagnostic for measuring the rms divergence and emittance of relativistic electron beams when the energy spread $\Delta\gamma/\gamma$ is less than the normalized rms divergence $\sigma = \gamma\theta_{rms}$. This is the case for most beams previously diagnosed with OTRI. To extend this diagnostic capability to beams with larger energy spreads, we have calculated the effects of all the parameters effecting the visibility of OTR interferences, V; i.e. energy spread, angular divergence, the ratio of foil separation to wavelength ratio, d/λ and filter bandpass. We have shown that: 1) for a given $\Delta\gamma/\gamma$, the sensitivity of V to σ is proportional to the observation angle θ_0, the fringe order **n** and the ratio d/λ ; 2) the sensitivity of V to $\Delta\gamma/\gamma$ is independent of θ_0 and **n** but is proportional to d/λ. Thus, by adjusting d/λ, and choosing the appropriate fringe order, one can separate out and measure *both* the energy spread and divergence. However, the filter bandpass must decrease with θ_0 and **n**. Results of our calculations will be given for various beams of interest.

PM02:

ANNULAR BEAM MONITORING USING OPTICAL TRANSITION RADIATION

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The development of power X-band cluster-klystrons requires to research the low-energy high-density annular beam structure with high resolution. An acceptable method is the investigation of the image created by optical transition radiation generated by the passage of a beam through a metal target. In this paper we represent the experimental data on measurement of the transverse current density distribution of the 30 keV annular beam with the current 5 A and the sub-millimeter wall thickness. The high magnetic field necessary for transportation of the high-density beam restricts the optical system aperture that defines the resolution and sensibility of this method. A digital photo camera was used to increase sensibility and possibility of image processing.

PM03:

STUDIES OF OTR ANGULAR DISTRIBUTION ON CTF2

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Today, Optical Transition radiation (OTR) is widely used in beam diagnostics. The most common application is the imaging of the transverse and longitudinal beam profiles. Other beam parameters like divergence and energy can also be deduced by observing the angular distribution of the OTR emission

("Donuts"). In order to investigate the possibilities and the limits offered by this technique we have performed a test on the *48MeV*, *1nC* electron beam of the CLIC Test Facility 2 (CTF2.).

Beam divergences between *2* and *6mrad* were measured with an accuracy of few percent. A good agreement was also found between the energy measurements obtained with a classical spectrometer and the OTR based technique. We conclude describing some possible future applications of OTR based diagnostics for CLIC.

PM04:

OTR FROM NON-RELATIVISTIC ELECTRONS

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The CLIC Test Facility 3 (CTF3) injector will provide pulsed beams of high average current; *5A* over *1.56μs* at *140keV*. For transverse beam sizes of the order of 1mm, as foreseen, this implies serious damages to the commonly used scintillating screens. Optical Transition Radiation from thermal resistant radiators represents a possible alternative. At low energy the OTR emission is feeble and distributed over a large solid angle.

In order to investigate the feasibility of such a diagnostic studies have been carried out on a test *80keV* photo injector. The experimental set-up is described and the results are compared to the calculations based on the OTR emission theory. Our conclusions for the design of the CTF3 injector profile monitor are also given.

PM05:

OPTICAL TRANSMISSION SYSTEM FOR STREAK CAMERA MEASUREMENTS AT PITZ

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The photoinjector injector test facility at DESY Zeuthen (PITZ) [1] produces electrons with a momentum of about 4 MeV/c. It is the aim to measure the temporal characteristics of the electron bunch train and single bunches with high accuracy of the order of 1 ps and less. Several types of streak cameras will be used in combination with different radiators which transform particle energy in light. The problem to be solved is the light transport over a distance of about 27m. Basic demands to the optical system and design principles will be explained. The optical and technical solutions will be presented. The strategy of adjustment and commissioning of the optical system will be described. The system contains switchable optics to use different radiators (OTR, Cherenkov radiators). Diagnostic tools are foreseen at different positions along the optical axis. The results of different measurements in the lab and using the original system will be presented. The problems on the minimalization of the time dipersion in the system will be discussed.

[1] F.Stephan, et al., Photo injector test facility under construction at DESY Zeuthen, FEL 2000, Durham

PM06:

AN IMPROVED PLL FOR TUNE MEASUREMENTS

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Phase locked loop (PLL) systems are being used on several machines for continuous tune measurements. All these implementations are based on a continuous sinusoidal beam excitation and a monitoring of the resulting beam oscillation.

The key element determining the dynamic performance of such a PLL is the phase detector between the beam oscillation and the internal oscillation. Most circuits use a quadrature phase detector, for which the high frequency carrier at twice the excitation frequency is attenuated by a low-pass circuit. The remaining ripple of this component contributes to the bandwidth/noise performance of the PLL.

In this paper we propose an alternative solution for the filter, notably an adaptive notch filter. We explain in detail design considerations and the resulting improvements in PLL bandwidth and/or noise figure.

PM07:

REAL TIME MANAGEMENT OF THE AD SCHOTTY/BTF BEAM MEASUREMENT

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The AD Schottky and BTF system relies on rapid acquisition and analysis of beam quantisation noise during the AD cycle which is based on an embedded receiver and digital signal processing board hosted in a VME system. The software running in the VME sets up the embedded system and amplifiers, interfaces to the RF and control system, manages the execution speed and sequence constraints with respect to the various operating modes, schedules measurements during the AD cycle and performs post processing taking into account the beam conditions in an autonomous way. The operating modes of the instrument dynamically depend on a detailed configuration, the beam parameters during the AD cycle and optional user interaction. Various subsets of the processed data are available on line and in quasi real time for beam intensity, momentum spread and several spectrum types, which form an important part of AD operation today.

PM08:

RECENT ADVANCES IN THE MEASUREMENT OF CHROMATICITY VIA HEAD-TAIL PHASE SHIFT ANALYSIS

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A so-called "Head-Tail" monitor has been operational in the CERN-SPS for a few years. The measurement of chromaticity using such a monitor relies on the periodic dephasing and rephasing that occurs between the head and tail of a single bunch for non-zero chromaticity. By measuring the turn-by-turn position data from two longitudinal positions in a bunch it is possible to extract the relative dephasing of the head and the tail, and so to determine the chromaticity. Until recently this technique had suffered from an unexplained “missing factor” when compared to conventional chromaticity measurements. This paper explains the source of this factor and also reports on the considerable experimental, simulation and analysis effort that has qualified the technique for use in the LHC.

PM09:

DIAGNOSTICS FOR ELECTRON COOLED BEAMS

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Nearly all modern hadron storage/accumulator rings use an electron cooling device to increase the phase space density of the circulating beam before its transfer to another accelerator or to the experiments. For fast and efficient cooling, the properties of the electron and hadron beams need to be monitored before, during and after the cooling process in a non-destructive manner in order not to perturb the normal operation of the machine.

In this paper we review the various techniques used to measure and optimise the different parameters that determine the quality of the cooling.

PM10:

THE FAST TUNE MEASUREMENT SYSTEM FOR THE ELETTRA BOOSTER

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A major upgrade of the ELETTRA injector is currently on going: the 1GeV LINAC will be replaced with a 100MeV LINAC and a 2.5GeV Booster Synchrotron. A new set of diagnostics is now under development for these two new machines. The new Fast Tune measurement system for the Booster represents a significant improvement as compared to the present Tune measurement system.

With the Booster cycling at 3Hz, horizontal and vertical tunes have to be measured during the energy ramp, whose duration is 160ms. To completely characterise the dynamics of the Booster during the energy ramp, a set of 25 tune values has been required, corresponding to a 6.4ms interval between successive measurements. The accuracy of this measurement is $<10^{-3}$. Such frequency spans are achievable using a Real Time Spectrum Analyser (Tektronix 3026), which is a fast sampling instrument with built-in FFT algorithm and data presentation.

In this paper, after describing the system specifications and architecture, we present the results of the preliminary tests, which have been carried out both in the laboratory and on the Storage Ring.

PM11:

BEAM STUDIES MADE WITH THE SPS IONIZATION PROFILE MONITOR

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During the last two years of SPS operation, investigations were pursued on the ability of the SPS ionization profile monitor prototype to fulfill different tasks. It is now established that the instrument can be used for injection matching tuning, by turn to turn recording of the beam size after the injection. Other applications concern beam size measurements on beams ranging from an individual bunch to a nominal SPS batch foreseen for injection into the LHC (288 bunches). By continuously tracking throughout the SPS acceleration cycle from 26 GeV to 450 GeV the evolution of parameters associated to the beam size, it is possible to explain certain beam behavior. Comparisons are also made at different beam currents and monitor gains with measurements made with the wire scanners. Data are presented and discussed, and the possible implementation of new features is suggested in order to further improve the consistency of the measurements.

PM12:

CAVITY MODE RELATED WIRE BREAKING OF THE SPS WIRE SCANNERS AND LOSS MEASUREMENTS OF WIRE MATERIALS

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During 2002 SPS running with the high intensity LHC type beam the breaking of several of the carbon wires in the wire scanners has been observed. This damage occurred with the scanners in their parking position. The observation of large changes in the wire resistivity and thermionic electron emission indicated clearly a strong RF beam induced heating and its bunch length dependence. A subsequent analysis in the laboratory, simulating the beam by a RF-powered wire, showed two main problems. The housing of the wire scanner acts as a cavity with a mode spectrum starting around 350 MHz and high impedance values around 700 MHz. The carbon wire used appears to be an excellent RF absorber and thus dissipates a significant part of the beam-induced power. The classical cavity mode technique is used to determine the complex permittivity and permeability of different samples. As a resonator, a rectangular TE_{01N} type device is used. Different materials such as silicon carbide (SiC), carbon and quartz fibres as well as other samples were measured, since no data for these materials was available. In particular SiC properties are of interest, since SiC bulk material is often used as a microwave absorber. As a result, the carbon wire will be replaced by a SiC wire, which shows much less RF losses. Placing ferrite tiles on the inner wall of the wire scanner housing considerably reduces the impedance of the cavity modes. The reduction of the Q values of these modes is confirmed by laboratory measurements.

PM13:

THE NEW PS BOOSTER FAST WIRE SCANNER

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The very tight emittance budget for LHC type beams makes precise emittance measurements in the injector complex a necessity. The PS machine uses 2 fast wire scanners per transverse plane for emittance measurement of the circulating beams. In order to ease comparison the same type of wire scanners have been newly installed in the upstream machine, the PS Booster, where each of the 4 rings is equipped with 2 wire scanners measuring the horizontal and vertical profiles.

Those wire scanners use new and more modern control and readout electronics featuring dedicated intelligent motor movement controllers, which relieves the very stringent real time constraints due to the very high speed of 20m/s. In order to be able to measure primary beams at the very low injection energy of the Booster (50MeV) secondary emission currents from the wire can be measured as well as secondary particle flows at higher primary particle energies during and after acceleration.

The solution adopted for the control of the devices is described as well as preliminary results obtained during measurements made in 2002.

PM14:

UPGRADE OF THE ESRF FLUORESCENT SCREEN MONITORS

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The ESRF injector system contains 23 Fluorescent Screen monitors: 4 in the TL-1 transferline (200MeV), 8 in the Booster, and 11 in the TL-2 transferline (6GeV). They are based on Chromium doped Alumina screens that are pneumatically inserted at 45deg. angle in the beam path with an optical system, at 90deg. angle, collecting and focusing the emitted light onto a low-cost CCD camera with standard 75ohm video output. Serving mainly alignment purposes in the past 10 years, the present upgrade aims at a 200um fwhm resolution for beam-size and profile measurements. The particularity of the Alumina screen not in vacuum but in atmosphere will be explained. Details of the mechanics, the optic system and a cost-efficient way of light flux adjustment will be given. The analysis of the factors determining the ultimate spatial resolution will show that it is dominated by the screen characteristics. Results obtained with different screen material will be presented.

PM15:

FIRST EXPERIMENTAL RESULTS AND IMPROVEMENTS ON PROFILE MEASUREMENTS WITH THE VIBRATING WIRE SCANNER

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The paper presents the first experimental results of transverse profile scans using a wire scanner based on a vibrating wire (vibrating wire scanner - VWS). The measurements were performed at the injector electron beam (6 nA) of the Yerevan synchrotron. The beam profile information is obtained by measuring the wire natural oscillations that depend on the wire temperature. This first experiments on weak electron beam proved this new method as a very sensitive tool, even suitable for tail measurements.

Additional, improvements were tested to overcome some problems connected with signal conditioning and signal transfer in the presence of electromagnetic noise. As a result the noises were neatly separated and reduced. A mathematical method for rejection of distorted data was developed. Experiments with the scanner at the PETRA accelerator at DESY are planned for measurements of beam tails.

PM16:

WIRE SCANNER BEAM PROFILE MEASUREMENT FOR ESRF

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Method of beam transverse profile measurement in accelerator by wire scanner is wide spread in accelerator field. The wire scanner is used in beam transfer lines of European Synchrotron Radiation Facility (ESRF) to provide data for beam profiles, which is being used in emittance measurements. The beam energy in the first transport line is 200 MeV and the peak current is 25 mA. The purpose of the scanner is to provide horizontal and vertical beam profiles. This work will discuss the operation of the wire scanner, and the first results of the scanner in ESRF. By changing the value of focus quad at (de focus quad= 18A) we get the emittance value for the vertical plane. The value is1.5x10-6 mrad. When we used this value to simulate our result we find that the simulation gives good fitting with real values of vertical plane. Also by changing the value of de focus quad at

(focus quad = 10.46A) we get the emittance value for the horizontal plane. The value is 2x10-7 mrad. And we find that the simulation gives good fitting with real values.

PM17:

DEVELOPMENT OF A PERMANENT MAGNET RESIDUAL GAS PROFILE MONITOR WITH FAST READOUT

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Modern ion accelerators and storage rings require very fast beam profile measurements (turn-by-turn) with highest resolutions. We propose a new residual gas monitor, which will operate on secondary electrons whose trajectories are localized within ∅ 0.1 mm filaments along 0.1 T uniform magnetic field lines excited by a permanent magnet. The best way to adopt the resolution of 0.1 mm into the data acquisition system is the use of a CCD camera with upstream MCP-phosphor screen assembly. To realize a fast turn-by-turn beam profile measurement a photodiode readout by a 100-channel amplifier/digitizer is foreseen.

PM18:

RESIDUAL GAS FLUORESCENCE FOR PROFILE MEASUREMENTS AT THE GSI UNILAC

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The high beam currents, delivered at the LINAC at GSI (UNILAC) can destroy intercepting diagnostics within one macro-pulse. As an alternative for a non-destructive profile measurement the methode for residual-gas-fluorescence is investigated. The fluorescence light is emitted by the N_2 molecules of the residual gas at the blue wavelength range and can be monitored with a modern CCD-camera. The images are transferred via digital bus (IEEE 1394 'FireWire') and the profiles are generated by analysis of the images with a modern software tool (National Instruments 'LabView'). Due to the short beam pulses (about 0.2 ms) the light intensities emitted by the residual gas are low and require a high amplification (gain > 10^6) which is realized with an image intensifier with double MCP (multi channel plate), connected with a fiber taper to the CCD-chip. The design parameters of the optics and electronics are discussed as well as the advantages of the digital data transmission.
Measurements with heavy ion beams of several 100 µAs and a comparison to other profile measurement methods show a good signal-to-noise ratio and prove a good applicability.

PM19:

IONISATION BEAM PROFILE MONITOR AT THE COOLER SYNCHROTRON COSY-JÜLICH

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For beam profile measurements, a residual-gas ionisation beam profile monitor using a position sensitive micro channel plate (MCP) detector was developed and installed at the cooler synchrotron and storage ring COSY at Forschungszentrum Jülich.

A parallel ion drift field is maintained in the gap between two electrodes. Residual gas ions are drifted onto an MCP assembly that provides a charge gain of about 10^7. For online calibration the detector can be illuminated with an α-source. The secondary charge produced from each ion is collected by a wedge and strip anode. After some processing the charge signal is digitized and red out by means of a PC running Cobold PC software.

Since COSY operates with beam intensities up to 10^{11} protons and a vacuum of 10^{-9} mbar, there is a high risk of detector damage. The lifetime of the channel plates and the event rate are crucial issues for the profile measurement of intense proton beams. The aging of the channel plates (i.e. inhomogeneous decrease of the gain) were investigated using scanning electron microscope and energy dispersive x-ray microanalysis. Different implemented detector protection mechanisms are discussed. Measurements with electron cooled beams are reported.

PM20:

ELECTRON BEAM EMITTANCE MEASUREMENT AT STORAGE RING WITH INTERNAL TARGET

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The method for measurement of electron beam axis position and angular beam spread is developed for a storage ring with internal target. The method is based on the usage of elastic scattering of high energy electrons (positrons) circulating in a storage ring on atomic electrons of the target. If the beam has a finite emittance and the azimuth is taken from the beam axis the distribution of the azimuth angel between Bhabha scattering positron and electron has a width proportional to the beam angular spread and a mean value depending on the magnitude of the displacement of the real storage ring close orbit position from ideal one. Monte Carlo simulation was made for the positron beam with a real angular dispersion for energy range typical for electron-proton collider HERA. The consideration can be generalize by taking into account the positron beam and the target polarization and final state radiation. This method can be used also at electron-positron and proton-proton colliders and at linear accelerators.

PM21:

RECENT DEVELOPMENTS OF THE EXCYT RADIOACTIVE BEAM DIAGNOSTICS

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The EXCYT radioactive beam facility at LNS, based on the ISOL (Isotope Separator On Line) technique, will start producing its first radioactive beams during 2004. We are setting up a suitable high sensitivity diagnostics, in order to guarantee a real time monitoring of the beam parameters (transversal profiles, ion composition and current), offering also the capability to perform the beam imaging at very low beam energy (50 keV). For this purpose, a simple technique based on the use of a thin CsI(Tl) scintillating plate that does not require any amplification system inside the beam pipe, has been employed. Tests performed with stable beams have shown a current sensitivity well below 10^5 pps, a value that can be improved by adopting a more suitable lens and an intensified and cooled CCD camera.

PM22:

ULTRASOUND EFFECTS AND METHODS IN PARTICLE ACCELERATORS

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Ultrasound excited in closed volumes conducting walls by particles and fields can be used for beam diagnostics and accelerator control with outer acoustic monitors. Ultrasound fields in conducting walls of circular accelerator vacuum chamber provide the experimental studies of circulating beam space-time characteristics, internal RF fields, low energy particle distributions (electron clouds, emission electrons captured in multipoles of magnet structure), location of multipactors inside vacuum chamber. In conducting walls of accelerating structures - studies of real structure characteristics under high RF power condition, beam losses distributions along the structure, electron emission and dark current distributions, location of breakdowns in the structure. In conducting walls of waveguides and metal structures of klystrons - location of breakdowns, tuning and control of high power klystrons. In beam transport line walls - studies and control of beam losses distributions along the line. The experience of ultrasound measurements at linear and circular accelerators in frequency range up to 7 MHz is described.

PM23:

NETWORK ATTACHED DEVICES AT SNS

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The Spallation Neutron Source (SNS) diagnostic instruments at Oak Ridge National Laboratory are based on the Network Attached Device (NAD) concept. Each pickup or sensor has its own resources such as timing, data acquisition and processing. NADs are individually connected to the network, thus reducing the brittleness inherent in tightly coupled systems. This architecture allows an individual device to fail or to be serviced or removed without disrupting other devices.

This paper describes our implementation of the nearly 400 NADs to be deployed. The hardware consists of rack-mounted PCs with standard motherboards and PCI data-acquisition boards. The software environment is based on LabVIEW and EPICS. LabVIEW supports the agile development demanded by modern diagnostic

systems. EPICS is the control system standard for the entire SNS facility. To achieve high performance, LabVIEW and EPICS communicate through shared memory.

SNS diagnostics are developed by a multi-laboratory partnership including ORNL, BNL, LANL, and LBNL. The NAD concept proved successful during the commissioning of the SNS front-end both at LBNL and ORNL.

PM24:

PARASITIC BUNCH MEASUREMENT IN e+/e– STORAGE RINGS

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The lepton storage rings DORIS and PETRA at DESY are used as sources for synchrotron radiation experiments. In normal operation the distance between the bunches should be 96 ns in PETRA and 192 ns in DORIS. The adjacent buckets must not have any stored particles or, in reality, as few as possible. This is particularly important for time triggered photon measuring experiments. The principle of the 'parasitic bunch' measurement down to a fraction of 10^{-6} of the main bunch within 20 seconds are described. Additionally, the sources of the 'parasitic bunches' and the actions to minimize them are discussed.

PM25:

DIAGNOSTICS OF THE PROSCAN BEAM LINES

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PROSCAN, an extended medical facility using proton beams for the treatment of deep seated tumours and eye melanoma, is now in preparation at PSI. A 250 MeV proton beam of 0.1 to 500 nA will be extracted from the COMET cyclotron. After degradation to 70 to 230 MeV it can be delivered (at a maximum current of 1 to 5 nA) into one of four areas: Two gantries, an eye treatment room and an irradiation area for various experiments. Fast changes of beam energy are foreseen for the spot-scanning treatment of deep-seated tumours in the gantries. Several diagnostics will be used to control the beam parameters in different modes of operation. An overview is given on the devices foreseen for the measurement of beam profile, position, current and losses in the beam lines.

PM26:

A SYSTEM FOR BEAM DIAGNOSTICS IN THE EXTERNAL BEAM TRANSPORTATION LINES OF THE DC-72 CYCLOTRON

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The isochronous four-sector Cyclotron DC-72 will serve as the basic facility of the Cyclotron Center of the Slovak Republic in Bratislava. It will be used for accelerating ion beams of H- to Xe up to energy of 72-2.7 MeV/nucleon.

In the present work a system for external beam diagnostics is presented, which is intended for on-line acquisition of data on the main parameters of accelerated beams (current, position, profile, emittance and energy

of the ion beams) to allow effective tuning of the accelerator operation regime as well as ion beam transport along the transport lines through the ion optical systems to physical targets and set-ups.

PM27:

MULTIFUNCTION TEST-BENCH FOR HEAVY ION SOURCES

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The new test-bench for heavy ion sources has been created in ITEP. It is planned to equip test-bench with a set of measurement devices to cover wide range of beam widths, divergences, durations, currents etc. It will provide measurements of different heavy ion beams parameters, particularly, emittance and charge state distribution. The last parameter may be measured both by the time-of-flight method and with the magnet analyzer. Two emittance measurement devices will be installed. It will be possible to use both slit/grid and CCD based "pepperpot" methods, which will give advantages of combination of classical emittance measurements with performance of the CCD based devices. The detailed description of test-bench and its equipment is presented. The first results at MEVVA ion source and beam investigations are discussed.

PM28:

BEAM DIAGNOSTICS FOR INTENSE HEAVY ION BEAMS AT THE GSI UNILAC

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With the new High Current Injector (HSI) of the GSI UNILAC the beam pulse intensity had been increased by approximately two orders of magnitudes. The HSI was mounted and commissioned in 1999; since this time the UNILAC serves as an injector for the synchrotron SIS, especially for high uranium intensities. Considering the high beam power of up to 1250 kW and the short stopping range for the UNILAC beam energies (□12 MeV/u), accelerator components could be destroyed, even during a single beam pulse. All diagnostic elements had to be replaced preferably by non-destructive devices. The beam current is mainly measured by beam transformers instead of Faraday cups, beam positions are measured with segmented capacitive pick-ups and secondary beam monitors instead of profile harps. The 24 installed pick-ups are also used to measure intensities, widths and phase of the bunches, as well beam energies by evaluating pick-ups at different positions. The residual gas ionization monitors allow on-line measurements of beam profiles. The knowledge of the real phase space distribution at certain position along the linac is necessary for optimizing the machine tuning, for the improvement of the matching to the synchrotron and for a better understanding of beam dynamic issues under space charge conditions. The paper will report the application of different beam diagnostic devices for the measurement of transverse beam emittances at different UNILAC beam energies and for different beam intensities. Additionally, measurements of the bunch structure after the HSI and a the design of a new device for the measurement of the longitudinal emittance at the end of the UNILAC will be included.

PM29:

A MODULAR VME DATA ACQUISITION SYSTEM FOR COUNTER APPLICATIONS AT THE GSI SYNCHROTRON

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Particle counters perform the control of beam loss and slowly extracted currents at the heavy ion synchrotron (SIS) at GSI. A new VME/Lynx – PC/Linux based data acquisition system has been developed to combine the operating purposes beam loss measurement, spill analysis, spill structure measurement and matrix switching functionality in one single assembly. In this paper a detailed PC-side software description is presented. To achieve best system stability, the software has been divided into time critical networking and data deploying threads and low or normal priority interface tasks. Some new abilities in the fields of data computation and presentation are reported. A hardware description is presented, in detail a programmable GSI-EVENT controller, which is based on an ordinary 8 bit RISC microprocessor and which has been integrated into the system, to synchronize the data acquisition with the sophisticated “virtual accelerator” timing at GSI. First experiences gained while the commissioning of the system are discussed.

PT01:

BEAM POSITION AND PHASE MEASUREMENTS USING A FPGA FOR THE PROCESSING OF THE PICK-UPS SIGNALS

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We have implemented the signal processing needed to derive the transverse beam position and the beam phase from the signals of a four electrodes BPM block on a FPGA (field programmable gate array). The high processing rate of a FPGA allows taking the full benefit of the high data acquisition rate of the most recent ADC circuits. In addition, it is possible to implement on a FPGA a processing algorithm exactly tailored to the measurement of the beam parameters. The efficiency of the signal processing has also been improved by a careful choice of the frequency of the sampling clock and of the RF front -end local oscillator, which are derived from the storage ring RF frequency. This paper describes the BPM, the RF front-end electronics and the FPGA algorithm. It presents some of the application of this BPM at ESRF and gives measurement results.

PT02:

PILL-BOX CAVITY BPM FOR TESLA CRYOMODULE

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A new cavity BPM with 10 micrometer resolution is designed and fabricated to perform single bunch measurements at the TESLA linear collider. In order to have a low energy dissipation in the cryogenic supermodule, the inner surface of the cavity is copper plated. Cross-talk is minimised by a special polarisation design. The electronics, at 1.5GHz, is a homodyne receiver normalised to the bunch charge. Its LO-signal for down-conversion is taken from the same cavity.

PT03:

INTELLIGENT, NETWORK ENABLED DIGITAL RECEIVER FRONT-ENDS

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Integration of analog RF front ends with associated digital receivers into a single intelligent module will make such complex systems look like single devices to the global control system. Such building blocks, which are suited for a variety of diagnostic and low-level RF applications, will require a different approach to system architecture and integration. Packaging of these devices will become a major issue and may require a technology without crates.

PT04:

ADVANTAGES OF IMPLEMENTING DIGITAL RECEIVERS IN FIELD PROGRAMMABLE GATE ARRAYS (FPGA)

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Today's state-of-the-art FPGA technology allows designers to satisfy almost any demand for high-speed data processing needed in DSP applications and fast data transfers. Dedicated FPGA resources are used in DSP applications to perform down conversion, filtering and data formatting. New trends in system architecture favor serial data transfer rather than parallel by using FPGA's internal resources, BRAMs, high speed serial IOs and hard core processors.

PT05:

EXPERIENCE WITH DIRECT SAMPLING OF 500 MHz RF SIGNAL FOR DIGITAL RECEIVER APPLICATIONS

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This article will present test results of a prototype system that was built to evaluate feasibility of a direct sampling of a 500 MHz RF signal for use in digital receiver applications. The system consists of a variable gain RF front end, a fast analog to digital converter (ADC) and a field programmable gate array (FPGA) providing glue-logic between the ADC and a PC computer.

PT06:

BEAM MOTION ALIASING ERRORS OF MULTIPLEXING BEAM POSITION MONITORS

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Multiplexing Beam Position Monitors (BPM) are widely used for their simplicity and inherent drift cancellation property. These systems successively feed the signals of (typically four RF) pickups through one single detector channel. The beam position is calculated from the demultiplexed (base band) signal. However, as shown by this contribution, transverse beam motion results in positional aliasing errors due to the finite multiplexing frequency. Fast horizontal motion, for example, can alias into an apparent, slow vertical position change. A thorough analysis is presented and the impact of essential parameters such as the multiplexing rate and the scanning pattern/sequence of classical 4-button pickups is discussed.

PT07:

CAVITY BEAM POSITION MONITOR FOR THE TESLA ENERGY SPECTROMETER

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In order to measure the beam position with a precision of better than 1μm in the TESLA energy spectrometer a cavity beam position monitor is proposed. The waveguide coupling is used to achieve a good common mode rejection and therefore a better precision. The paper gives a short overview of the monitor functionality and describes resolution measurements which were made on the cavity prototype.

PT08:

THE LHC ORBIT AND TRAJECTORY SYSTEM

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This paper describes the definitive acquisition system selected for the measurement of the closed orbit and trajectory in the CERN-LHC and its transfer lines. The system is based on a Wide Band Time Normaliser (WBTN) followed by a 10-bit ADC and a Digital Acquisition Board (DAB), the latter developed by TRIUMF, Canada. The complete chain works at 40MHz, so allowing the position of each bunch to be measured individually. In order to avoid radiation problems with the electronics in the LHC tunnel, all the digital systems will be kept on the surface and linked to the analogue front-ends via a single mode fibre-optic connection. Slow control via a WorldFIP fieldbus will be used in the tunnel for setting the various operational modes of the system and will also be used to check power supply statuses. As well as describing the hardware involved, some results will be shown from a complete prototype system installed on four pick-ups in the CERN-SPS using the full LHC topology.

PT09:

CAVITY-TYPE BPMs FOR THE TESLA TEST FACILITY FREE ELECTRON LASER

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For measurements of the beam position at the undulator section of the TESLA Test Facility (TTF) at DESY cavity-type beam position monitors were developed, installed and brought into operation. Besides of some theoretical aspects results of in-beam measurements at the TTF are presented and pros and cons of this monitor concept are discussed.

PT10:

ENHANCEMENT OF BEAM STABILITY AND TURN-BY-TURN SYSTEM AT HLS

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During the past year, we have tried several ways to improve the stability of injected beam at Hefei Light Source (HLS) which has newly upgraded its injection system. To overcome the evident betatron oscillation, we built one specific betatron-oscillation suppressor circuitry to take it under control. We have tried several means to excite and damp beam motions, as well as a PLL circuit to track the variation of tune under various machine states. In addition, we improve the performance of early version of turn by turn system and rebuilt the software kit to make it an reliable instrumentation for beam nonlinear dynamics study and machine state monitoring.

PT11:

EXPERIMENT AND APPLICATION OF TURN BY TURN SYSTEM IN INJECTION COMMISSION OF HLS

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In paper, we introduce the turn by turn system of HLS , and present the analysis for experiment results, as well as its application in upgraded injection commission of HLS. The signal processor of the system adopt log-ratio electronics circuit. Injection kickers are used to excite beam forβoscillation. Up to 2 seconds data acquisition is ensured.

PT12:

BEAMPHASE MEASUREMENT IN THE AGOR CYCLOTRON

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Beamphase measurement to optimize the isochronism is an essential part of the diagnostics in multi-particle, multi-energy cyclotrons. In the AGOR cyclotron an array of 13 nondestructive beamphase pick-ups is installed. To reduce the large disturbances from the RF-system the measurements are traditionally performed at the 2^{nd} harmonic of the RF-frequency. To further improve the sensitivity intensity modulation of the beam has been introduced. This creates side-bands in the Fourier spectrum, that are completely free of interference from the RF-system. These side-bands contain information on both the beamphase with respect to the accelerating voltage and the number of revolutions up to the radius of the measurement. A specific case is intensity modulation at the orbital frequency, where the side-bands contain only information on the beamphase. Measurements with the different methods will be presented, demonstrating that the intensity modulation strongly improves the sensitivity of the measurement. Useful beamphase measurements can now be made for beam intensities down to 10 nA.

PT13:

AN X-BAND CAVITY DESIGN FOR A HIGH PRECISION BEAM POSITION MONITOR

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The next generation of accelerators will require increasingly precise control of beam position. For example designs for the next linear collider require beam-position monitors (BPMs) with 200 nm resolution. The accelerator designs also place difficult requirements on accuracy and stability. To meet these requirements a cavity BPM operating at 11.424 GHz was designed. The BPM consists of two cavities: an xy-cavity tuned to the dipole mode and a phase cavity tuned to the monopole mode. The xy-cavity uses a novel coupling scheme that (in principal) has zero coupling to the monopole mode. This report will present the mechanical design, simulations, and test results of a prototype BPM. In addition BPM designs with even higher precision will be discussed.

PT14:

DESIGN OF BPM PU FOR LOW-BETA PROTON BEAM USING MAGIC CODE

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We have designed the BPM PU based on capacitive buttons for use in the KOMAC (Korea Multi-purpose Accelerator Complex), the high-intensity proton linac that are under development at the KAERI (Korea Atomic Research Institute), Korea. The KOMAC is aiming to produce CW 20-mA beam current at the 100-MeV energy. We have chosen the button-type PU since it is easier to fabricate than other type PUs including the stripline, and it could provide enough signal power because of the high beam current. The PU sensitivity was calculated by the MAGIC that is a kind of the Particle-In-Cell code that originates from the plasma science community. The utilization of the MAGIC code is especially useful for BPM PUs in the low-beta sections of the accelerator, because it is difficult to obtain the PU sensitivity experimentally due to the difficulties in simulating the low-beta beams by the electromagnetic waves in a test bench. In this presentation, we report on the design of the BPM PU based on the MAGIC calculation.

PT15:

PERFORMANCE OF THE MODIFIED ELBE BPM ELECRONICS

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The ELBE radiation source is based on a superconducting linac. Initially it was designed to be used in CW mode with repetition rates either 13 MHz either 260 MHz. Later it was decided to operate the accelerator with reduced repetition rates for diagnostic reasons and for certain users. Now it is possible to operate at repetition rate 13/n MHz, where n can be 2,4,8,16,32,64 and 128. It is required that the BPM system supports any of these operation modes. A core element of the BPM electronics is a logarithmic amplifier AD8313 made by Analog Devices Inc. The logarithmic amplifier is a direct RF to DC converter rated up to 2,5 GHz. Initial design of the BPM electronic was sophisticated only for CW operation with repetition rate more than 10 MHz, since

bandwidth of the AD8313 is about of 10 MHz. Additionally a sample and hold amplifier is built in to provide enough time for an ADC to make measurements. The sample and hold amplifier is synchronized with a micropulse frequency. In the paper we present results of the modified BPM electronics test.

PT16:

A HIGH DYNAMIC-RANGE BEAM-POSITION MEASUREMENT SYSTEM FOR ELSA-2

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New beamlines are presently under construction for ELSA, a 20 MeV electron linac located at Bruyères-le-Châtel. These lines need a beam position measurement system filling the following requirements: small footprint, wide dynamic range, single-bunch/multi-bunch capability, simple design. We designed a compact 4-stripline sensor and an electronic treatment chain based on logarithmic amplifiers. This paper presents the design, cold and hot test results.

PT17:

IMPEDANCE-MATCHING-TRANSFORMER FOR CAPACITIVE PICK-UPS

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The transfer line from the GSI heavy ion synchrotron (SIS) to the experimental set ups is equipped with segmented capacitive pick-ups for beam position measurement. This beam position measurement will be designed to cover a dynamic range of 160dB and single-bunch evaluation. For taking measurements with maximum sensitivity the best choice is a high-impedance tap at the pick-up referring to the bunch length of 50...500 ns. Therefore the feeding of 50 Ohm coax-cables will be realized by an impedance-matching-transformer located close to the pick-up. It has an impedance >10 kOhm at the primary side and 50 Ohm matching at the secondary side with a foreseen bandwidth of 200 MHz. So it is possible to use low noise amplifiers with 50 Ohm input in a radiation-safe environment without loading the pick-up with 50 Ohm. A specialized impedance-matching-transformer is now under development and the result will be presented.

PT18:

DEVELPOPMENT OF A BUNCH FREQUENCY MONITOR FOR THE PRELIMINARY PHASE OF THE CLIC TEST FACILITY CTF3

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In the framework of the CLIC RF power source studies, the feasibility of the bunch train combination by injection with RF deflectors into an isochronous ring has been successfully demonstrated in the preliminary phase of CTF3. In order to monitor this scheme, a new method based on beam frequency spectrum analysis was experimented. For this purpose, a coaxial pick-up and its detection system were designed and mounted in the CTF3 ring, in order to allow comparison of the amplitudes of five harmonics of the fundamental beam frequency (3 GHz) while combining bunch trains. The commissioning of the monitor was a successful proof of principle

for this new method, despite the short length of the bunch trains and the presence of parasitic signals associated to high-order wave guide modes propagating with the beam inside the pipe.

PT19:

TRANSVERSE FEEDBACK SYSTEM FOR THE COOLER SYNCHROTRON COSY-JÜLICH – FIRST RESULTS

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The cooler synchrotron COSY delivers unpolarized and polarized protons and deuterons in the momentum range 300 MeV/c up to 3.65 GeV/c. Electron cooling at injection level and stochastic cooling covering the range from 1.5 GeV/c up to maximum momentum are available to prepare high precision beams for internal as well as for external experiments in hadron physics. In case of electron cooled beam the intensity is limited by transverse instabilities. The major losses are due to the vertical coherent beam oscillations. To damp these instabilities a transverse feedback system is under construction. First results with a simple feedback system are presented. Due to the feedback system operation the intensity and lifetime of the electron cooled proton beam at injection energy could be significantly increased. Measurements in frequency and time domain illustrate the performance of the system.

PT20:

A NEW WIDE BAND WALL CURRENT MONITOR

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Wall current monitors (WCM) are commonly used to observe the time profile of particle beams. In CTF3, a test facility for the future CERN Linear Collider CLIC, high current electron beams of 1.5 μs pulse length are bunched at 3 GHz and accelerated in a Linac working in fully loaded mode, for which a detailed knowledge of the time structure along the pulse is mandatory. The WCM design is based on an earlier version developed for CTF2, a previous phase of the test facility, in which the beam duration was only 16 ns. Due to the longer pulse width the low frequency cut-off must be lowered to 10 KHz while the high frequency cut-off must remain at 10 GHz. The new WCM therefore has two outputs: a direct one for which an increase of the inductance results in a 250 kHz to 10 GHz bandwidth while the second one, using an active integrator compensating the residual droop, provides a 10 KHz to 300 MHz bandwidth. The new WCM has been installed in CTF2 late 2002 in order to test its high frequency capabilities prior to its use in CTF3. Design considerations and first results are presented.

PT21:

MICROWAVE MEASUEMENT OF INTRA BUNCH CHARGE DISTRIBUTIONS

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A direct way of obtaining intra bunch charge distributions is to measure the amplitude roll off as well as the phase behavior of the spectrum of the single bunch self field. To that effect, a microwave pickup together with a microwave front end has been installed in the storage ring of the Swiss Light Source (SLS). As pickup, button

type bpms are used, which have been designed for a broad band behavior in the excess of 30 GHz. Three bpms together with their individual front ends are used in order to sample the beam spectrum at frequencies of 6, 12 and 18 GHz, which compares to the standard spectrum of a 1 mA single bunch extending to approximately 12 GHz (13 ps rms bunch length). The signals are mixed to base band in loco using the multiplied RF frequency as a LO. By shifting the LO phase, simultaneously the amplitude roll off as well the complex phase of the beam spectrum can be obtained. Where using a resonator as a pickup would smear out the response over several bunches, allowing only the determination of average values, the current setup has a band width of approximately 2 GHz, so that individual bunches in the 500 MHz bunch train can easily be resolved.

PT22:

MEASUREMENT OF THE LONGITUDINAL PHASE SPACE AT THE PHOTO INJECTOR TEST FACILITY AT DESY ZEUTHEN

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The photo injector test facility at DESY Zeuthen (PITZ) has been developed with the aim to deliver low emittance electron beams and study its characteristics for future applications at free electron lasers and linear accelerators. The energy of the electron beam varies in the range between 4 and 5 MeV. One of the important properties of the delivered beam is the longitudinal phase space of the electron beam. Measurements of the momentum distributions show a small energy spread. The principle of the measurement of the bunch length will be discussed, time resolutions will be shown and preliminary results will be given. The design to measure the correlation between momentum and time distribution of the electron bunch will be shown with calculated resolutions.

PT23:

TRANSVERSE EMITTANCE MEASUREMENTS AT THE PHOTO INJECTOR TEST FACILITY AT DESY ZEUTHEN

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The main research goal of the Photo Injector Test Facility at DESY Zeuthen (PITZ) is the development of electron sources with minimized transverse emittance like they are required for the successful operation of Free Electron Lasers and future linear colliders. The process of electron beam optimization requires characterization of the transverse emittance at a wide range of operation parameters. The design and functionality of the emittance measurement system at PITZ is presented. The methods applied as well as the resolution limits of the system are discussed. The latest measurements of the transverse properties of the electron beam are presented.

PT24:

DEVELOPMENT OF A BUNCH-LENGTH MONITOR WITH SUB-PICOSECOND TIME RESOLUTION AND SINGLE-SHOT CAPABILITY

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A bunch-length monitor with single-shot capability is under development at the 100 MeV pre-injector LINAC of the Swiss Light Source (SLS). It is based on the electro-optical effect in a ZnTe crystal induced by coherent transition radiation (CTR). A spatial autocorrelation of the CTR in the EO-crystal rotates the polarisation of a mode-locked Nd:YAG laser to produce an image on an array detector representing the Fourier components of the CTR spectrum. Up to now a theoretical model for the emission of transition radiation has been developed in order to design optics allowing efficient transport of the CTR onto the EO-crystal. The frequency dependency of the CTR due to the finite size of the target screen has been measured in the sub-THz regime at the SLS Linac. The results strongly support the theoretical descriptions of the radiation source. By expanding the intensity pattern in higher-order Laguerre-Gaussian modes, the transmission through the optical transfer system is calculated.

PT25:

CHARACTERISATION OF FAST FARAFDAY CUPS AT THE ELETTRA LINAC

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Since several years, the Diagnostic Group at Laboratori Nazionali di Legnaro (LNL) has been designing Fast Faraday Cups (FFC) to be used on their Heavy Ion Accelerators; latest developments in this field include a stripline FFC, jointly developed with SNS, Oak Ridge. A collaborative partnership has been set-up between LNL and ELETTRA Laboratory to fully characterize new FFCs, using as electron source the ELETTRA 1GeV Linac. Two FFCs, the stripline FFC, built at SNS, and a coaxial FFC, made at LNL, have been installed at ELETTRA who provided the wideband data acquisition and the remote control of the measurement. The first measurements carried out using 1GHz oscilloscope allowed the proper set-up of remote control and a low jitter triggering. Wideband measurements were performed with a sampling scope equipped with 50GHz head whereas the bandwidth of the stripline FFC is in the order of 10GHz.

A complete set of tests has been carried both on the coaxial FFC and on the stripline FFC. Thanks to the information provided by these wideband measurements, the Linac working point has been further optimized as well as the injection process into the ELETTRA SR.

PT26:

CRYOGENIC CURRENT COMPARATOR FOR ABSOLUTE MEASUREMENTS OF THE DARK CURRENT IN THE TEST CRYOSTAT CHECHIA

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A newly high performance SQUID based measurement system for detecting dark currents, generated by superconducting cavities for TESLA is proposed. It makes use of the Cryogenic Current Comparator principle and senses dark currents in the nA range with a small signal bandwidth of 70 kHz.

To reach the maximum possible energy in the TESLA project is a strong motivation to push the gradients of the superconducting cavities closer to the physical limit of 50 MV/m. The field emission of electrons (the so called dark current) of the superconducting cavities at strong fields may limit the maximum gradient. The absolute measurement of the dark current in correlation with the gradient will give a proper value to compare and classify the cavities.

This contribution describes a Cryogenic Current Comparator (CCC) as an excellent and useful tool for this purpose. The most important component of the CCC is a high performance DC SQUID system which is able to measure extremely low magnetic fields, e.g. caused by the extracted dark current. For this reason the SQUID input coil is connected across a special designed pick-up coil for the electron beam. Both the SQUID input coil and the pick-up coil form a closed superconducting loop so that the CCC is able to detect dc currents down to 2 pA/√ Hz. Design issues and the application for the CHECHIA cavity test stand at DESY as well as preliminary experimental results are discussed.

PT27:

A 40MHz BUNCH BY BUNCH INTENSITY MEASUREMENT FOR THE CERN SPS AND LHC

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A new acquisition system has been developed to allow the measurement of the individual intensity of each bunch in a 40MHz bunch train. Such a system will be used for the measurement of LHC type beams after extraction from the CERN-PS right through to the dump lines of the CERN-LHC. The method is based on integrating the analogue signal supplied by a Fast Beam Current Transformer at a frequency of 40MHz. This has been made possible with the use of a fast integration ASIC developed by the University of Clermont-Ferrand, France, for the LHC-b pre-shower detector. The output of the integrator is digitised using a 12-bit ADC and fed into a Digital Acquisition Board (DAB) that was originally developed by TRIUMF, Canada, for use in the LHC orbit system. A full system set-up was commissioned during 2002 in the CERN-SPS, and following its success will now be extended in 2003 to cover the PS to SPS transfer lines and the new TT40 LHC extraction channel.

PT28:

CURRENT MEASUREMENTS OF LOW-INTENSITY BEAMS AT CRYRING

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The demand for new ion species leads to an increasing number of cases in which the ions can only be produced in small quantities. Thus, weak ion currents quite often have to be handled in low energy ion storage ring, like CRYRING. Various detector systems have been developed to measure such low intensity coasting and bunched beams by using the overlapping ranges of those systems.

1. We have extended the RMS resolution to 1 nA of the Bergoz Beam Charge Monitor (BCM) by using a low noise 60 dB preamplifier for the Integrating Current Transformer.
2. The sum signal of a capacitive pick-up is integrated by a second gated integrator and the BCM output signal is used for calibration. The RMS resolution is about 100 pA.
3. To measure the coasting beam intensity, neutral particle detectors have been built. The fast Microchannel plate detector can handle 1 Mc/s, and a 50 Mc/s Secondary Electron Multiplier based detector is under construction. On the magnetic flat top, 100 ms is available to calibrate the count rate of the neutral particle detectors during each machine cycle.

PT29:

DARK CURRENT MEASUREMENT AT THE PITZ RF GUN

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For photoelectron rf guns with acceleration gradients of 40 MV/m or higher at the photo cathode operated at the rf pulse length of 100 μs or more, the amount of dark current might be comparable with the photoelectron beam. Strong dark current can cause multipacting, radiation damages and cryogenic losses. At the photo injector test facility at DESY Zeuthen (PITZ) the dark current was measured with various solenoid setups at the rf gun by Faraday cup. We compare the dark current behavior of different photo cathodes. Experimental results are discussed with simulations.

PT30:

IONISATION CHAMBERS FOR THE LHC BEAM LOSS DETECTION

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At the Large Hadron Collider (LHC) a beam loss system will be used to prevent and protect super-conducting magnets against coil quenches and coil damages. Since the stored particle beam intensity is 8 orders of magnitude larger than the lowest quench level value particular attention is paid to the design of the secondary particle shower detectors. The foreseen ionisation chambers are optimised in geometry simulating the probable loss distribution along the magnets and convoluting the loss distribution with the secondary particle shower distributions. To reach the appropriate coverage of a particle loss and to determine the quench levels with a relative accuracy of 2 the number of the detectors and their lengths is weighted against the particle intensity density variation.

In addition attention is paid to the electrical ionisation chamber signal to minimise the ion tail extension. This optimisation is based on time resolved test measurements in the PS booster.

A proposal for a new ionisation chamber will be presented.

PT31:

OPTICAL FIBRE DOSIMETER FOR SASE FEL UNDULATORS

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Single pass Free Electron Lasers (FELs) based on self-amplified spontaneous emission (SASE) are developed for high brightness and short wavelength applications. They use permanent magnet undulators which are radiation sensitive devices. During accelerator commissioning beam losses can appear anywhere along the undulator line. To avoid damage of the permanent magnets due to radiation, an optical fibre dosimeter system can be used. The increase of absorption caused by ionizing radiation is measured in radiation sensitive optical fibers. The dose system enables relatively fast particle loss tuning during accelerator operation and allows the monitoring of the accumulated dose. Dose measurements in narrow gaps which are inaccessible for any other (online) dosimeter type become possible. The electromagnetic insensitivity of optical fibre sensor is an advantage of applications in strong magnetic undulator fields. At each location the light absorption is measured by using an optical power-meter. The dynamic range is about 50 dB and covers the linear range of the dose calibration of the fibre. The resolution of the system is 140 mGy. The time between successive measurements is about 5 minutes. The system was installed and successfully tested at the TESLA Test Facility TTF1. The fibre sensors will be a standard diagnostic tool in the soft X-ray user facility TTF2.

PT32:

BEAM LOSS DIAGNOSTIC BASED ON TOTAL AND PARTIAL PRESSURE MEASUREMENTS

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The GSI is operating a heavy ion synchrotron, which is currently undergoing an upgrade towards higher beam intensities. It was discovered that beam losses induce a significant pressure increase in the vacuum system. In order to detect the time constants of the pressure increase and decrease, fast total pressure measurements were put into operation. With the recently installed partial pressure diagnostics it is also possible to follow up which types of molecules are released. The presentation will focus on the different techniques applied as well as on some measurement results. The potential and difficulties of this diagnostic tool will also be discussed.

PT33:

BEAM LOSS MONITOR FOR PEFP

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A beam loss monitor system is being fabricated for PEFP (Proton Engineering Frontier Project) by Korea Atomic Energy Research Institute (KAERI) and high dose rate test will be conducted at KAERI gamma irradiation facility that provides exposure rate of 10^6 R/h. It is based on air-filled ion chambers and an electrometer. We will discuss the collection efficiency and stability of the ion chamber with respect to different radiuses of anode electrode. The proper choice of high voltage bias polarity for the ion chamber will be also studied.

PT34:

DAΦNE BEAM LOSS MONITOR SYSTEM

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At the DAFNE collider a beam loss monitor system has been installed to continuously monitor the particle losses. The acquisition is based on 32 Bergoz beam loss monitors, of the Wittenburg type, installed close to the main rings vacuum chamber, buffering monitoring circuitry and a counting scale (SIS 3801) as acquisition board. We developed a front-end software that allows acquiring the integrated value of the BLM counts and a stream of 1000 point for each monitor, to cover an history of 3000 s. The operator program allows displaying the instantaneous BLM values over the machine together with a representation of the past history.

D. PARALLEL DISCUSSION SESSIONS

DW01:

MACHINE PROTECTION AND INTERLOCK SYSTEMS

Discussion animators: K. Wittenburg (e-mail: kay.wittenburg@desy.de)
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The purpose of a MPS is to protect the equipment against abnormal beam behaviour. High intense and high brilliant particle, photon and X-ray beams are capable of causing significant damage to components in a fraction of a second, i.e. too fast for any human reaction. The aim of this session is to discuss existing and planned MPS with both their specific and their general requirements. Among points to be reviewed: the choice of sensors and components, the logic, the strategy, etc. in view of the need for the MPS to be fail-proof. Some typical questions that will be raised: What are the criteria for determining that an alarm situation has been reached and what is the subsequent action of the system? Very often the MPS may allow different beam modes, depending on beam permit inputs. Which kind of beam modes exist and what are the input signals? How are these systems integrated with the accelerator controls and what is the impact on their operation?

This session will include a few very brief presentations of existing and planned MPS' from different machines to illustrate the above questions and to stimulate the subsequent discussion.

DW02:

GLOBAL ACCELERATOR NETWORK, CONTROL SYSTEMS AND BEAM DIAGNOSTICS

Discussion animators: U. Raich (e-mail: Ulrich.Raich@cern.ch)
and H. Schmickler (e-mail: Hermann.Schmickler@cern.ch)

Falling funds force all accelerator centers to look for new sources of financing and for the most efficient way of implementing new projects. This very often leads to collaborations between institutes scattered around the globe, a problem well known to big high energy physics experiments. The collaborations working on big detectors e.g. for LHC started thinking about detector acquisition and control systems which can be remotely used from their respective home institutes with minimal support on the spot.

This idea was taken up by A. Wagner from DESY for the TESLA machine, who proposed the “Global Accelerator Network” (GAN) enabling users from around the world to run an accelerator remotely.

Questions around this subject that immediately come to mind:

- Is the GAN only relevant to big labs ? Or is it reasonable e.g. for operators or engineers in charge to do certain manipulations from home?
- Are our instruments ready for the GAN?
- Does the fact of being “GAN ready” increase the cost of the instruments?
- What are the advantages and disadvantages?
- Do we want these features? or do inconveniences prime over advantages?
- Do any of the labs already have experience with GAN or any system going into this direction?
- What does GAN mean for the relationship between controls and beam diagnostics (a sometimes difficult chapter)?
- Can measurement systems be put onto the WEB and if yes, which ones
- Where are the limitations?
- Can the scope of GAN be expanded to “remote diagnostics and active maintenance” of equipment, i.e. collaborating partners maintain their product in service after commissioning.
- What about common machine experiments with people sitting in different control rooms?
- What communication systems have to be put in place for this?
- Are there security issues and how do we deal with them?

DW03:

BEAM SYNCHRONOUS TIMING SYSTEMS

Discussion animators: A. Peters (e-mail: A.Peters@gsi.de)
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For many beam diagnostics purposes beam synchronous timing systems are needed in addition to the timing systems supplied by the control systems of the different accelerators. The demands and techniques of different accelerator facilities will be discussed along the following aspects:

- Bunch and macro pulse synchronous timing systems
- Solutions for different time scales from ps to ms
- Coupling to the RF and control systems of the different accelerators
- Electronics for the beam synchronous timing systems: parameters, techniques, controlling
- Use of industrial products for bunch synchronous timing systems, e.g. function generators
- Distribution of the timing signals: electronically via cables, optically via fibres or wireless
- Coupling to and use of timing standards: IRIG-B, GPS, …

The participants should present and describe solutions from their facilities with some transparencies as a starting point for the discussion.